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CT255 Assignment 2
Rainbow Tables

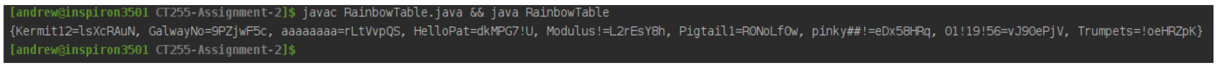
2022-11-06

1 Problem 1

1.1 Code

```java
import java.util.HashMap;

/*  CT255 Assignment 2
 *  This class provides functionality to build rainbow tables (with a different reduction function per round) for 8 character long strings, which
    consist of the symbols "a .. z", "A .. Z", "0 .. 9", "!" and "#" (64 symbols in total).
    Properly used, it creates the following value pairs (start value - end value) after 10,000 iterations of hashFunction() and reductionFunction():
          start value  -  end value
          Kermit12        lsXcRAuN
          Modulus!        L2rEsY8h
          Pigtail1        R0NoLf0w
          GalwayNo        9PZjwF5c
          Trumpets        !oeHRZpK
          HelloPat        dkMPG7!U
          pinky##!        eDx58HRq
          01!19!56        vJ90ePjV
          aaaaaaaa        rLtVvpQS
          aaaaaaaa        klQ6IeQJ


 *
 * @author Michael Schukat
 * @version 1.0
 */
public class RainbowTable
{
    public static void main(String[] args) {
        long res = 0;

        // String array of the known passwords
        String[] passwords = {"Kermit12", "Modulus!", "Pigtail1", "GalwayNo", "Trumpets", "HelloPat", "pinky##!", "01!19!56", "aaaaaaaa", "aaaaaaaa"};

        HashMap<String, String> rainbowTable = new HashMap<>(); // declaring a HashTable that i'll use to store the password : hash pairs


        // looping through the passwords array
        for (String start : passwords) {
            if (start.length() != 8) {
                System.out.println("Input " + start + " must be 8 characters long - Exit");
            }
            else {
                String hash = start;                             // declaring a String hash that will hold the final reduced hash of a given password

                // hashing & reducing the start String 10000 times.
                for (int i = 0; i < 10000; i++) {
                    hash = reductionFunction((hashFunction(hash)), i);
                }

                // adding the password & its hash value to the rainbowTable HashMap
                rainbowTable.put(start, hash);
            }
        }
        // printing out the contents of the rainbowTable
        System.out.println(rainbowTable);
    }

    private static long hashFunction(String s){
        long ret = 0;
        int i;
        long[] hashA = new long[]{1, 1, 1, 1};

        String filler, sIn;

        int DIV = 65536;

        filler = new String("ABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGH");

        sIn = s + filler; // Add characters, now have "<input>HABCDEF..."
        sIn = sIn.substring(0, 64); // // Limit string to first 64 characters

        for (i = 0; i < sIn.length(); i++) {
            char byPos = sIn.charAt(i); // get i'th character
            hashA[0] += (byPos * 17111); // Note: A += B means A = A + B
            hashA[1] += (hashA[0] + byPos * 31349);
            hashA[2] += (hashA[1] - byPos * 101302);
            hashA[3] += (byPos * 79001);
        }

        ret = (hashA[0] + hashA[2]) + (hashA[1] * hashA[3]);
        if (ret < 0) ret *= -1;
        return ret;
    }

    private static String reductionFunction(long val, int round) {  // Note that for the first function call "round" has to be 0,
        String car, out;                                            // and has to be incremented by one with every subsequent call.
        int i;                                                      // I.e. "round" created variations of the reduction function.
        char dat;

        car = new String("0123456789ABCDEFGHIJKLMNOPQRSTUNVXYZabcdefghijklmnopqrstuvwxyz!#");
        out = new String("");

        for (i = 0; i < 8; i++) {
            val -= round;
            dat = (char) (val % 63);
            val = val / 83;
            out = out + car.charAt(dat);
        }

        return out;
    }
}
```

1.2 Output



```
[andrew@inspiron3501 CT255-Assignment-2]$ javac RainbowTable.java && java RainbowTable
{Kermit12=lsXcRAuN, GalwayNo=9PZjwF5c, aaaaaaaa=rLtVvpQS, HelloPat=dkMPG7!U, Modulus!=L2rEsY8h, Pigtail1=R0NoLf0w, pinky##!=eDx58HRq, 01!19!56=vJ90ePjV, Trumpets=!oeHRZpK}
[andrew@inspiron3501 CT255-Assignment-2]$
```

2 Problem 2

2.1 Code

```java
import java.util.HashMap;

/*  CT255 Assignment 2
 *  This class provides functionality to build rainbow tables (with a different reduction function per round) for 8 character long strings, which
    consist of the symbols "a .. z", "A .. Z", "0 .. 9", "!" and "#" (64 symbols in total).
    Properly used, it creates the following value pairs (start value - end value) after 10,000 iterations of hashFunction() and reductionFunction():
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 * @author Michael Schukat
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 */
public class RainbowTable
{
    public static void main(String[] args) {
        long res = 0;

        // String array of the known passwords
        String[] passwords = {"Kermit12", "Modulus!", "Pigtail1", "GalwayNo", "Trumpets", "HelloPat", "pinky##!", "01!19!56", "aaaaaaaa", "aaaaaaaa"};

        HashMap<String, String> rainbowTable = new HashMap<>(); // declaring a HashTable that i'll use to store the password : hash pairs


        // looping through the passwords array
        for (String start : passwords) {
            if (start.length() != 8) {
                System.out.println("Input " + start + " must be 8 characters long - Exit");
            }
            else {
                String hash = start;                             // declaring a String hash that will hold the final reduced hash of a given password

                // hashing & reducing the start String 10000 times.
                for (int i = 0; i < 10000; i++) {
                    hash = reductionFunction((hashFunction(hash)), i);
                }

                // adding the password & its hash value to the rainbowTable HashMap
                rainbowTable.put(start, hash);
            }
        }
        // printing out the contents of the rainbowTable
        System.out.println(rainbowTable);

        // chain lookup section
        // long array of the 4 hashes to be searched for
        long[] hashes = {895210601874431214L, 750105908431234638L, 111111111115664932L, 977984261343652499L};

        // for each loop that loops through each hash in the array of hashes
        for (long hash : hashes) {

            // looping 10000 times to search for the password - this will function as our max number of iterations, as 10000 iterations should just take use back to where we started.
            for (int i = 0; i < 10000; i++) {
                // reducing the hash
                String str = reductionFunction(hash, i);
                // checking if the reduced hash is a key (password) in the rainbowTable HashMap
                if (rainbowTable.containsValue(str)) {
                    System.out.println("Found password " + str + " for hash value " +  hash);   // printing the found password
                    break;                                                                      // breaking out of the for loop
                }
                else {
                    hash = hashFunction(str);                                                   // hashing str before continuing the for loop
                }
            }
        }
    }

    private static long hashFunction(String s){
        long ret = 0;
        int i;
        long[] hashA = new long[]{1, 1, 1, 1};

        String filler, sIn;

        int DIV = 65536;

        filler = new String("ABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGHABCDEFGH");

        sIn = s + filler; // Add characters, now have "<input>HABCDEF..."
        sIn = sIn.substring(0, 64); // // Limit string to first 64 characters

        for (i = 0; i < sIn.length(); i++) {
            char byPos = sIn.charAt(i); // get i'th character
            hashA[0] += (byPos * 17111); // Note: A += B means A = A + B
            hashA[1] += (hashA[0] + byPos * 31349);
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            hashA[3] += (byPos * 79001);
        }

        ret = (hashA[0] + hashA[2]) + (hashA[1] * hashA[3]);
        if (ret < 0) ret *= -1;
        return ret;
    }

    private static String reductionFunction(long val, int round) {  // Note that for the first function call "round" has to be 0,
        String car, out;                                            // and has to be incremented by one with every subsequent call.
        int i;                                                      // I.e. "round" created variations of the reduction function.
        char dat;

        car = new String("0123456789ABCDEFGHIJKLMNOPQRSTUNVXYZabcdefghijklmnopqrstuvwxyz!#");
        out = new String("");

        for (i = 0; i < 8; i++) {
            val -= round;
            dat = (char) (val % 63);
            val = val / 83;
            out = out + car.charAt(dat);
        }

```
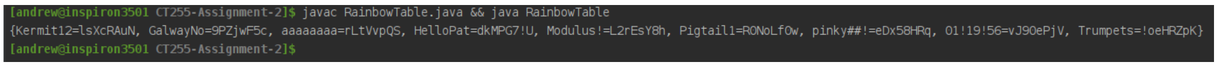

```java
            return out;
        }
}
```

2.2 Output

I couldn't actually find a password match with the above code, and I'm not sure why. My current guess would be that the reduction function wasn't being called properly, as everything else *seemed* to be working as expected. I didn't call the reduction more than 10,000 times as that would theoretically just lead me back to the same place in the chain. I think that my problem is with the passing of the integer `i` to the reduction function, as I think that I correctly implemented the rest of the steps for performing a chain lookup - I input a hash value, reduce it, check if the reduced form is in the list of final plaintexts (the "Values" in the HashMap), and if so break out of the loop (but this never occurs), assigning the relevant "Key" from the HashMap as the original plaintext password that produced the original input hash. Otherwise, I continue until I'm back at the same place in the chain after the 10,000th iteration, where the code gives up.



```
[andrew@inspiron3501 CT255-Assignment-2]$ javac RainbowTable.java && java RainbowTable
{Kermit12=lsXcRAuN, GalwayNo=9PZjwF5c, aaaaaaaa=rLtVvpQS, HelloPat=dkMPG7!U, Modulus!=L2rEsY8h, Pigtail1=RONoLfOw, pinky##!=eDx58HRq, 01!19!56=vJ90ePjV, Trumpets=!oeHRZpK}
[andrew@inspiron3501 CT255-Assignment-2]$
```